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PROBABLE IMPACTS OF BUDGET REDUCTIONS ON THE DEVELOPMENT AND US--ETC(U)
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BY THE U.S. GENERAL ACCOUNTING OFFICE
Report To The Chairman, Subcommittee On
Energy Conservation And Power
Committee On Energy And Commerce
House Of Representatives

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**Probable Impacts Of Budget Reductions
On The Development And Use Of
Photovoltaic Energy Systems**

Federal expenditures for the development of photovoltaic energy systems have been substantially reduced. Funding for the Federal photovoltaic program for fiscal year 1982 is \$74 million, approximately one-half of the previous year's level.

At the funding levels existing prior to the fiscal year 1982 budget reductions, the 1988 photovoltaic energy systems cost and production goals mandated by the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 had little likelihood of being reached. With these budget reductions, however, achievement of these goals is even more unlikely. Additionally, the budget reductions may also have an adverse impact on U.S. leadership in photovoltaic energy technology and on the ability of small businesses in the industry to survive.

Nevertheless, the outlook for the widespread use of photovoltaic energy in this century appears favorable. The industry is expected to endure despite reduced Federal support, and continue its development of this technology.

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UNITED STATES GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

ENERGY AND MINERALS
DIVISION

B-206660

The Honorable Richard L. Ottinger
Chairman, Subcommittee on Energy
Conservation and Power
Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

In your letter dated July 17, 1981, you requested that we examine the impact of the reductions in the fiscal year 1982 Federal photovoltaic research and development (R&D) budget on the achievement of certain goals established by the Congress in the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 (P.L. 95-590, Nov. 4, 1978). As you specifically requested, we focused our work on the impact the budget reductions may have on the act's fiscal year 1988 goals of

--reducing average installed photovoltaic energy system cost to \$1.40 per peak watt, 1/ and

--reaching a total annual photovoltaic energy system production of 2 million peak kilowatts.

Additionally, as requested by your office, we obtained information on the probable impacts of budget reductions on U.S. leadership in photovoltaic energy technology and on small businesses in the photovoltaic industry.

As you know, the administration has substantially reduced the budget for the Federal program to develop solar photovoltaic energy systems. Such systems convert sunlight into electricity and, when economical, could provide a significant source of energy for the Nation. The Department of Energy (DOE) had been conducting an aggressive photovoltaic program, which included activities in research and development, testing, demonstrations, and

1/The act specified an installed system cost of \$1 per peak watt. However, in accordance with section 10 of the act, the Department of Energy updated this cost goal in terms of 1980 dollars (\$1.40 per peak watt), and reported this change to the Congress. For consistency, we refer to the cost goal, and all other figures, in 1980 dollars.

market development, to bring about the economical use of photovoltaic energy systems as quickly as possible. However, the administration has reduced the program's budget, limiting funding primarily to advanced research and development. As a result, many of the activities in the Federal photovoltaic program have been curtailed or eliminated. Funding for the program, which was originally \$160 million in fiscal year 1981, has been reduced to \$74 million in fiscal year 1982. 1/

SUMMARY OF FINDINGS
AND CONCLUSIONS

The details of our review are discussed in appendix I to this letter, and the results are highlighted as follows. Our review showed that the act's goals had little likelihood of being achieved prior to the fiscal year 1982 budget reductions; however, due to these reductions, the goals now have even less likelihood of being reached. Specifically,

- achieving the \$1.40 per peak watt system cost goal was unlikely without budget reductions, although there was some optimism that it could have been reached. However, systems currently cost approximately \$18 per peak watt, and neither the Federal program nor private industry is now expected to undertake the efforts needed to reduce these costs and achieve the goal in the 1988 time frame,
- the act's 1988 production goal of 2 million peak kilowatts had a very low probability of being attained prior to the budget reductions, but with the budget reductions, the remaining possibility of reaching this goal by 1988 has been essentially eliminated.

In addition to its impact on the achievement of the mandated goals, there are concerns about the ability of the United States to maintain its leadership in photovoltaic technology and of small businesses in the photovoltaic industry to survive. The United States is currently the world leader in photovoltaic technology, but reduced Federal funding, coupled with increased support to foreign photovoltaic industries by their respective governments, has caused concern about whether U.S. leadership can be maintained. The primary concern centers around the efforts of Japan, which is aggressively pursuing the development of photovoltaic technology. Additionally, with the reduced Federal program, small businesses in the photovoltaic industry may not survive

1/The administration's proposed budget for fiscal year 1983 requests \$27 million for photovoltaic energy development, a reduction of 64 percent from the fiscal year 1982 level.

since they are not expected to be able to obtain funds necessary to compete successfully with larger businesses.

Despite the probable impacts of the administration's budget reductions, however, the photovoltaic industry is expected to endure and the act's goals ultimately achieved, albeit at a later date. While the goals of the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 are not likely to be reached by 1988, industry is expected to continue efforts to develop economical photovoltaic energy technologies. Consequently, while photovoltaic energy systems will no longer be developed as quickly as possible with Federal funding reduced to fiscal year 1982 levels, the achievement of the goals is believed possible in the early to mid-1990s, and the widespread use of photovoltaic energy systems may yet be attained in this century.

SCOPE AND METHODOLOGY

In responding to your request, we obtained information only on the probable impacts of the fiscal year 1982 budget reductions. We did not address possible impacts of funding at the budget level proposed for fiscal year 1983. We examined the status and potential of solar photovoltaic energy systems and the objectives of the Federal photovoltaic program, which is managed by DOE, reviewed the activities being performed under the Federal program, and interviewed DOE program officials in Washington, D.C., responsible for the conduct of the Federal photovoltaic program. We also interviewed officials of the National Aeronautics and Space Administration in Washington, D.C.; the Jet Propulsion Laboratory, in Pasadena, California; the Solar Energy Research Institute in Golden, Colorado; and the Sandia National Laboratories in Albuquerque, New Mexico; all of whom are involved in conducting portions of the Federal photovoltaic program for DOE. We obtained and reviewed past and current budgets, multi-year program plans, and various studies relating to the development and use of photovoltaic energy systems and the achievement of the legislatively mandated goals. We also reviewed documents at the various laboratories which discuss the status of efforts to improve photovoltaic technology and the actions still needed to make this technology economically competitive with conventional sources of electricity. Additionally, we obtained and reviewed reports produced by other groups relating to photovoltaic energy development and the Federal program, in particular reports by DOE's Solar Photovoltaic Energy Advisory Committee and by the Solar Energy Industries Association. We also discussed photovoltaic energy development with representatives of these groups, as well as the Electric Power Research Institute.

Further, we contacted and discussed photovoltaic energy development with 19 firms. The firms included both large and small companies from all parts of the country. We discussed with representatives of these firms the current state of photovoltaic

development, prospects for the future, and the impacts of Federal funding reductions. We also used, where applicable, results from a previous GAO study, "Industry Views on the Ability of the U.S. Photovoltaics Industry to Compete in Foreign Markets" (ID-81-63, Sept. 15, 1981), which included information from over 30 companies and from U.S. embassies overseas on the effects of the budget reductions on the ability of U.S. firms to compete with foreign photovoltaic industries. We also contacted three market research and four investment firms to obtain their opinion on the viability of investing risk capital in photovoltaic firms in light of the budget reductions. Appendix II contains a listing of companies contacted.

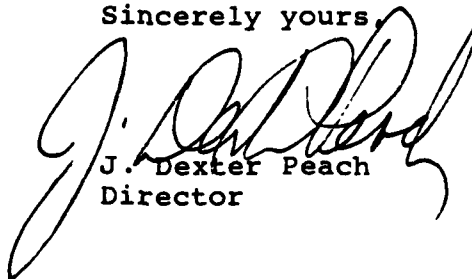
Our review was performed in accordance with GAO's current "Standards for Audit of Governmental Organizations, Programs, Activities, and Functions."

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As requested by your office, we did not obtain agency comments on this report, but, as agreed, we did discuss the report with DOE officials within the Office of the Assistant Secretary for Conservation and Renewable Energy. They generally agreed with our conclusions.

We are sending copies of this report to the Chairmen, House Committee on Energy and Commerce and the House and Senate Committees on Appropriations, the Secretary of Energy, and other interested parties. We will also make copies available to others upon request.

Sincerely yours,



J. Dexter Peach
Director

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ABBREVIATIONS

DOE	Department of Energy
JPL	Jet Propulsion Laboratory
R&D	Research and Development
SERI	Solar Energy Research Institute
Wp	Peak Watt



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PROBABLE IMPACTS OF BUDGET REDUCTIONSON THE DEVELOPMENT AND USE OFPHOTOVOLTAIC ENERGY SYSTEMS

By letter dated July 17, 1981, the Chairman of the Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, requested the General Accounting Office to examine the impacts of the reductions in the fiscal year 1982 Federal photovoltaic research and development (R&D) budget on the achievement of the goals set forth in the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 (Public Law 95-590, Nov. 4, 1978). The Chairman specifically requested that we examine the impacts the budget reductions may have on the act's fiscal year 1988 goals of

--reducing average installed photovoltaic energy system cost to \$1.40 per peak watt (Wp) 1/, and

--reaching a total annual photovoltaic energy system production of 2 million peak kilowatts.

The Chairman's office also requested that we obtain information on the probable impacts of budget reductions on U.S. leadership in photovoltaic energy technology and on small businesses in the photovoltaic industry.

BACKGROUND

Photovoltaic energy systems are a particularly attractive energy alternative which could play a significant role in the Nation's energy future. The energy source used by photovoltaic energy systems--sunlight--is free and inexhaustible. Additionally, these systems require no moving parts, have potentially long lives, require little maintenance, and are generally without adverse environmental consequences. The Department of Energy's (DOE's) past estimates of the potential energy contribution from photovoltaics showed that these systems could provide as much as 1 quad 2/ of energy by the year 2000, and, in the longer term,

1/The act specified an installed system cost of \$1/Wp. However, in accordance with section 10 of the act, DOE updated this cost goal in terms of 1980 dollars (\$1.40/Wp), and reported this change to the Congress. For consistency, we refer to the cost goal, and all figures, in 1980 dollars.

2/One quad equals one quadrillion British thermal units, or the equivalent of 293 billion kilowatt hours of electricity.

eventually as much as 30 percent of the Nation's total electricity requirements.

Photovoltaic energy systems are unique in that they convert sunlight directly into electricity. A photovoltaic system generally consists of photovoltaic cells (also known as solar cells), grouped together into collectors (also called modules), and the balance-of-system components, such as wiring, supporting structures, and power conditioners to make the electricity compatible with present electrical systems. Photovoltaic cells represent the heart of a photovoltaic energy system and are produced from semiconductor materials, primarily silicon. These materials create an electrical charge when struck by photons ^{1/} contained in sunlight. This action causes electrons to be freed from the atoms contained in the semiconductor materials, thereby generating a flow of electrical charges which can be drawn off through externally connected wires.

Photovoltaic energy systems have widespread applicability and could be used in virtually any area of the country to produce electricity. However, to have a substantial energy impact, photovoltaic energy systems need to be used in areas normally served by conventionally generated electricity. Consequently, they are viewed as an energy source for

- distributed applications, such as residences, to replace energy generated and distributed over conventional electric grids, and

- centralized utility applications to provide electricity for distribution through the grids.

Currently, however, the cost of photovoltaic energy systems is too high to permit their economical use in any of these grid-connected applications. While system costs vary, a typical system currently costs a purchaser about \$18/Wp or higher. ^{2/} At current prices, photovoltaic energy systems are economical in certain remote applications not connected to the utility grid, such as communications relay stations and ocean signal buoys, but they are

^{1/}A photon is a quantity of electromagnetic radiation.

^{2/}Because the output of photovoltaic systems vary depending on the time of day, weather conditions, and time of year, they are rated at their maximum, or peak, power production. For comparison purposes, a 5 peak kilowatt system at current peak watt prices would cost over \$90,000 for a typical residence and would produce electricity at a cost of \$.50 to \$2.00 per kilowatt hour.

approximately 10 times too expensive for use in grid-connected applications.

Recognizing the potential of solar photovoltaic energy systems, the Congress mandated a Federal program aimed at reducing the cost and bringing about the widespread use of this technology. The Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 legislated an aggressive Federal program of research and development leading to early economical use of photovoltaic technology. The stated objective of the act was to make the production of electricity from photovoltaic energy systems cost-competitive with utility-generated electricity from conventional sources. In this regard, the act mandated two goals for the program, namely:

- To reduce the average cost of installed solar photovoltaic energy systems to \$1.40 per peak watt by fiscal year 1988.
- To double the production of solar photovoltaic energy systems each year during the decade starting with fiscal year 1979, measured by the peak generating capacity of the systems produced, so as to reach a total annual U.S. production of solar photovoltaic energy systems of approximately 2 million peak kilowatts, and a cumulative production of approximately 4 million peak kilowatts, by fiscal year 1988.

To achieve these goals, the act established a 10-year program which was projected to cost \$1.5 billion.

DOE has overall management responsibility for the Federal photovoltaic energy program. The objective of the program, as stated in DOE's September 1980 draft "National Photovoltaics Program Multi-Year Program Plan," is to develop photovoltaic energy systems capable of supplying a significant portion of the Nation's energy needs. To this end, DOE established economically competitive photovoltaic systems price goals for the mid-1980s, and a long-range goal of achieving at least 1 quad of energy from photovoltaics by the year 2000. According to DOE's draft plan, the program is consistent with the goals and intent of the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978.

DOE's program centers on research, development, and demonstration activities. These activities are carried out under the following five major subprograms.

- Advanced R&D, which investigates photovoltaic cell concepts, materials, and structures leading to very low-cost photovoltaic devices.

- Collector Technology Development, which develops new and existing photovoltaic technologies into more effective, less costly photovoltaic collectors.
- Systems Development, which develops components of a photovoltaic energy system other than collectors.
- Tests and Applications, which carries out experiments and field tests to obtain performance information and to prove that the various system components can be integrated into viable systems.
- Market Development, which assists private sector efforts to bring cost-effective photovoltaic systems to the commercial market.

DOE has delegated the day-to-day management responsibilities for these subprograms to the Solar Energy Research Institute (SERI) in Golden, Colorado, and the Jet Propulsion Laboratory (JPL) in Pasadena, California. SERI has the lead for advanced R&D and JPL for the remaining subprograms. JPL is assisted in its collector technology development and systems development subprograms by the Sandia National Laboratories in Albuquerque, New Mexico.

BUDGET REDUCTIONS IN THE PHOTOVOLTAIC PROGRAM

The funding for DOE's photovoltaic energy program has declined substantially since fiscal year 1981. As a result, many of the program's activities are being reduced or eliminated.

Funding for DOE's photovoltaic energy program has been reduced from an appropriated level of \$160 million for fiscal year 1981 to less than one-half of that amount--\$74 million--in fiscal year 1982. ^{1/} While the program's funding in the past was close to levels DOE believed consistent with the act's overall \$1.5 billion estimate, it is now considerably below that amount, as shown in the following table.

^{1/}The Congress appropriated \$78 million for the photovoltaic energy program, but DOE applied \$4 million of that amount to a congressionally imposed general budget reduction.

Comparison of Required
and Actual Program Budgets
(millions)

<u>Fiscal year</u>	<u>Required budget (note a)</u>	<u>Actual funding</u>
1979	\$119	\$104
1980	157	150
1981	160	<u>b/</u> 152
1982	170	74

a/Required budget levels are those presented by DOE in its September 1980 draft National Photovoltaic Program Multi-Year Program Plan as being consistent with P.L. 95-590's overall \$1.5 billion budget level.

b/Although the program was appropriated \$160 million for fiscal year 1981, subsequent rescissions reduced funding for this fiscal year to \$152 million.

The Federal photovoltaic energy program is experiencing considerable change as a result of the budget cuts. According to budget documents and DOE officials, the budget cuts are a consequence of the administration's philosophy to concentrate Federal efforts on long-term, high-risk R&D with high potential pay-offs, leaving near-term R&D and commercialization efforts to private industry to perform. Consequently, the systems development and market development subprograms are being eliminated, and the tests and application subprograms limited to three projects. Additionally, the activities under both the advanced R&D and collector technology development subprograms have been substantially reduced. DOE officials stated that those remaining efforts will continue to be aimed at solving the long-range problems with photovoltaic technologies in regard to new photovoltaic concepts and materials, and, to a more limited extent, current silicon technology.

IMPACTS OF BUDGET REDUCTIONS
ON ATTAINMENT OF GOALS

The 1988 photovoltaic energy system cost and production goals set forth in the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 had little likelihood of being attained under past program efforts and funding. The budget reductions are expected to slow the development of photovoltaic technology and make the attainment of the goals more unlikely.

Likelihood of achieving cost goal has been reduced

Achieving the act's 1988 photovoltaic energy system cost goal of \$1.40/Wp would have been difficult under the past program scope and funding. Although its achievement was considered unlikely, some program and industry officials were optimistic that it could have been reached. However, under the current program funding, the advances needed to achieve cost reductions are expected to be slowed, and the goal has even less likelihood of being reached by 1988.

Reaching photovoltaic energy system costs of \$1.40/Wp by 1988 would have been difficult at funding levels consistent with the act. While the Federal program is credited with major contributions towards reducing system costs from over \$100/Wp to their current \$18/Wp level, substantial advances would be needed to reduce costs to less than one-tenth of the current level by 1988 in order to achieve the cost goal. For example, photovoltaic collectors, the major component of a photovoltaic energy system accounting for approximately one-half of its cost, are currently priced about \$9 to \$10/Wp, and according to DOE, costs of photovoltaic collectors must drop below \$.70/Wp for the act's goal to be reached. According to program officials and industry representatives, the production of photovoltaic collectors at this cost level would require technological breakthroughs in all collector materials and production areas. It was generally agreed by program officials and industry representatives that achieving the needed breakthroughs by 1988 was unlikely.

However, there was some optimism that the program could have reached, or come close to reaching, the cost goal at program funding levels consistent with the act's \$1.5 billion budget. Program officials at DOE, JPL, and SERI stated that substantial cost reductions could have been attained through activities aimed at

- reducing silicon materials costs,
- lowering photovoltaic cell production and collector assembly costs,
- reducing balance-of-system costs, and
- developing new photovoltaic materials and concepts with potential for very low cost.

The officials stated that, if successful, these activities could have possibly led to achievement of the goal. Program officials added that, with regard to photovoltaic collectors, they had already developed technology in the program which, if fully developed and used in commercial processes, could potentially produce collectors costing \$2.80/Wp. Consequently, they believed the

possibility existed that, with continued advancements, the cost goal could have been reached by 1988.

However, with the decrease in the budget, program officials believe that there is now little chance the act's 1988 cost goal can be achieved. According to JPL and SERI officials responsible for day-to-day management of the program, a number of activities needed to reach the goal have either been terminated or reduced. For example:

- Efforts to develop amorphous silicon, a material with potential for use in producing very low cost solar cells, have been reduced from five planned research approaches to one approach. Reductions have been made in other advanced materials areas, including work related to high efficiency materials and low cost polycrystalline thin films.
- A pilot plant to incorporate new technology to produce silicon at one-fourth its current costs was eliminated.
- Work on the engineering of effective and efficient systems has been cut by more than 50 percent, including efforts to lower the cost of balance-of-system components, which currently account for about one-half of the total cost of a photovoltaic system.

Because of the cutbacks in the program, JPL and SERI officials stated that the milestones they planned to meet in 1982--the commercial production of collectors costing \$2.80/Wp, photovoltaic systems priced at \$6 to \$13/Wp, and the development of a new solar cell technology with the potential to lower costs further--will no longer be met. They added that consequently the program is no longer on course to meeting the cost goal on time.

DOE program officials agreed that the program is no longer undertaking the efforts necessary to achieve the cost goal. They stated that with the current funding constraints they are precluded from undertaking efforts of the magnitude needed to achieve the goal. DOE officials added that the administration no longer considers achievement of the cost goal to be a proper role for the Government since its achievement would involve efforts to get products into the marketplace, which the administration contends is a role that should be left for private industry. DOE program officials stated that private industry must consequently undertake the near-term R&D necessary to bring competitively priced photovoltaic systems into the marketplace if the cost goal is to be met.

However, our discussions with industry representatives indicate that the cost goal will not be reached by industry with reduced Government assistance. Almost 60 percent of the 19 firms

...the photovoltaic energy development was contacted and it was pointed out that potentially could have been achieved under previous funding levels; none believe the goal could be reached in 1988 at the funding levels such as those called for in the fiscal year 1980 act. Industry representatives indicated that the reduced Federal support will cause industry to proceed more cautiously and increase its R&D. They said that generally the photovoltaic industry will not be able to pick up and fund the R&D activities previously funded by the Government since

the development of photovoltaic technology is viewed as high-risk;

the R&D costs are expected to be high, and many firms have insufficient capital to fund the necessary R&D; and

the return on investment is too long, compared to alternative uses, for industry to spend substantial amounts on photovoltaic technology.

From our discussions with photovoltaic firms that less than 10 percent indicated that they would increase R&D expenditures to carry on the R&D activities that previously were Government-funded. The other 83 percent of the firms indicated that their R&D expenditures would remain at past levels, and in some cases, would even be reduced.

Consequently, industry representatives agreed with program officials' opinions that the cost goal will not be met. Industry representatives stated that, with the Federal budget reductions, the technology advances will be slower and the resulting reduction in photovoltaic systems costs will take longer. They added that the aggressive approach of the past Federal program cannot be continued by industry and that the achievement of \$1.40/Wp for photovoltaic systems by 1988 is very unlikely.

Probability of attaining production goal essentially

The Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 mandated that the program achieve a photovoltaic energy systems production level of 2 million peak kilowatts in 1988; however, there was an extremely low probability of attaining that goal prior to the budget reductions. With the budget reductions, the probability of attaining the production goal has essentially been eliminated.

The specific goals of the act was that the production of photovoltaic systems double each year, so that by 1988 annual production would reach a level of 2 million peak kilowatts, and total production over that period would be 4 million peak

kilowatts. The legislative history of the act indicates that the Congress included the production goal because it was concerned that the small production capacity of the photovoltaic industry may limit the role photovoltaic systems could play in electricity production in this century.

However, within the time frames and funding envisioned by the act, the attainment of the production goal had a very low probability of success. The act projected that a program of 10 years duration and a total expenditure of \$1.5 billion would be needed. In 1980, DOE conducted an analysis of what would be needed to reach the production goal and concluded that the goal could not be attained at the funding level projected in the act. As stated in a February 1980 DOE report entitled "Federal Policies to Promote the Widespread Utilization of Photovoltaic Systems,"

"* * * a major conclusion emerging from this report is that, even under optimistic assumptions, the specific quantity of output goal suggested in Subsection (1) is not likely to be attained within the \$1.5 billion multi-year budget projection provided in the Act."

According to DOE's analysis, the probability of achieving this goal at the \$1.5 billion level was less than 5 percent. Officials who assisted in the analysis stated that, to attain the production goal, significantly more funding would be needed. The report indicates that for the goal to be attained, funding at a \$5 billion level would be needed, of which \$3.8 billion would be for market development activities. The higher funding level would be needed to purchase or subsidize purchases of photovoltaic energy systems to maintain an annual doubling of production until they reach an economically competitive level and the private sector could provide sufficient demand for these systems.

Analysis of current levels of photovoltaic energy production supports DOE's conclusion that the production goal will not be met. According to figures reported in a January 1981 study, "Photovoltaics 1980--The Growth Continues" by Strategies Unlimited, a market research firm specializing in alternative energy sources, production of photovoltaics is at lower levels than that required to be on course with meeting the act's goal, and, in general, the production rates have not been doubling, as shown in the following table.

Annual Photovoltaic Production
(peak kilowatts of production)

<u>Year</u>	<u>Production level needed to reach act's goal (note a)</u>	<u>Actual production (note b)</u>
1978	2,000	950
1979	4,000	1,450
1980	8,000	c/ 3,250
1981	16,000	c/ 5,000

a/Needed production levels are based upon an annual doubling of production and would equal 2.048 million peak kilowatts of production in 1988 if this doubling were maintained.

b/Production figures represent photovoltaic modules produced and shipped, as reported by Strategies Unlimited.

c/Estimated.

While the production goal would most likely not be met at the act's projected funding level, the cutbacks in the Federal photovoltaic program efforts will further limit production of photovoltaic energy systems. The Federal Government had been purchasing a significant amount of photovoltaic systems, and had been an important factor in the past production growth. According to Strategies Unlimited's study, Federal purchases were expected to account for over one-third of all photovoltaic systems purchased in 1980. However, Federal purchases only increased an estimated 20 percent in 1981, and Strategies Unlimited representatives and program officials monitoring photovoltaic production stated that photovoltaic purchases by the Federal program are expected to increase only slightly, or not at all, in 1982. While the private sector market remains strong, the lack of growth in Federal purchases will hold the anticipated 1982 production levels to about 8,000 to 9,000 peak kilowatts, far from the 32,000 peak kilowatts needed in 1982 to be on course to achieving the production goal. JPL officials who assisted DOE in analyzing actions needed to achieve the production goal stated that consequently, with reduced Federal purchases and the likely slower decreases in photovoltaic system costs, the probability of achieving the 2 million peak kilowatt production goal, even though it was previously very low, is now essentially eliminated.

Representatives of the photovoltaic industry agreed that the production goal will not be met by 1988. None of the industry representatives we surveyed believe this goal would be met under either the previous or current funding levels.

OTHER IMPACTS OF PHOTOVOLTAIC
BUDGET REDUCTIONS

The budget reductions for the Federal photovoltaic energy program are expected to have adverse impacts on U.S. leadership in the development and use of photovoltaic energy systems and on small businesses' involvement in photovoltaics. As viewed by officials in the Federal photovoltaic energy program and representatives of the photovoltaic industry, the budget reductions

- threaten U.S. leadership in photovoltaic energy, and
- may force small businesses out of the industry.

U.S. leadership in photo-
voltaics may be threatened

The United States has been the world leader in photovoltaics since the inception of this technology. The first practical photovoltaic cells were produced by the Bell Laboratories in the 1950s, and photovoltaic systems have been used extensively in the U.S. space program. Due in part to this early development and expertise in photovoltaic systems, the United States has maintained a leadership position in the terrestrial use of photovoltaic systems. U.S. photovoltaic manufacturers controlled about 85 percent of the worldwide photovoltaic market in 1979 and 1980.

However, many Government and industry officials believe that this position is threatened by the reductions in the Federal program. Companies in France, Germany, and Japan currently produce photovoltaic energy systems, and these companies receive support from their respective governments. While, for the most part, the funding of photovoltaics by other countries is not as large as U.S. funding, their support for photovoltaics is increasing as U.S. support is being reduced. Industry representatives pointed in particular to the willingness of foreign governments to get involved in market development activities, particularly demonstration projects, which they feel greatly enhance the visibility and marketability of photovoltaic energy systems.

A particular concern to many industry representatives and Government officials is Japan's aggressive photovoltaic efforts. According to officials at JPL who have been monitoring Japan's efforts, Japanese funding for photovoltaics has now equaled or surpassed U.S. funding and the Japanese photovoltaic industry may soon pose a serious threat to U.S. leadership. JPL and SERI officials noted, for example, that Japan is concentrating heavily on amorphous silicon technology, and that Japanese funding for this technology has increased to \$5.7 million, while Federal funding is reduced to \$2.8 million. The SERI official in charge of the Federal amorphous silicon efforts stated that Japanese companies are developing substantial experience and knowledge on

producing amorphous silicon solar cells by using this photovoltaic technology in consumer products. Consequently, because of their extensive R&D and the worldwide market channels which they have already established for electronic components, industry representatives and Government officials believe there is a greater likelihood that the Japanese may be first to develop photovoltaic energy systems with prices competitive with conventionally generated electricity, and be in a dominant position in regard to the worldwide photovoltaic energy market.

Industry representatives and Government officials are hopeful that the United States will maintain its leadership in photovoltaics, but they believe it will be increasingly difficult. As stated by one program official at JPL, the United States is playing by one set of rules, in which the Government does not interfere with the marketplace, while foreign countries have different rules, which allow their governments to aid the production and marketing of photovoltaic energy systems. He added that this places the U.S. photovoltaic industry at a disadvantage which may be difficult to overcome.

Small businesses may not survive

The Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 required that at least 10 percent of funds authorized be set aside for small businesses. According to DOE, the photovoltaic program provided over 15 percent of its funds, more than \$20 million, to small businesses over the past year. Representatives of small businesses and Government officials stated that the Federal program provided R&D funds to many small firms which otherwise could not afford to perform R&D. Additionally, the program provided a considerable amount of information to these firms on improvements and advancements in near-term photovoltaic technology. These factors enabled many small businesses to compete in the photovoltaic field.

However, the reductions in the Federal photovoltaic program are expected to make it difficult for small businesses in the photovoltaic industry to survive. It was widely agreed by industry representatives and Government officials that the budget reductions will most severely impact on small business. They pointed out that, whereas large businesses generally have access to the funds necessary to continue research to improve photovoltaic technology, small businesses are generally more reliant on the Federal program for research funds and are not in a financial position to continue to make the necessary investment in R&D.

Additionally, venture capital for small businesses in the photovoltaic industry is not expected to be widely available. Only one of four venture capital firms we contacted indicated that it would be willing to invest in small photovoltaic companies. Most of the firms indicated that photovoltaic technologies are too

far from large-scale commercial viability to justify their investment. Representatives of these firms added that substantial R&D expenditures will be required to make these technologies economical, and that they do not have the funds to compete with the large businesses in photovoltaic energy development. They stated that investments in photovoltaic energy companies are simply not as attractive as other, more profitable and secure industries.

Consequently, with limited access to capital, small businesses will have a difficult time remaining in the photovoltaic industry. Five of the nine small businesses we contacted indicated that they were having problems, and were reducing workforces, terminating certain R&D efforts, and considering selling out to, or merging with, larger corporations. Most small businesses indicated that, if the Federal Government continues to reduce its photovoltaic program, few if any small businesses will survive in the photovoltaic industry.

DESPITE PROBABLE ADVERSE IMPACTS,
OUTLOOK FOR WIDESPREAD USE OF
PHOTOVOLTAICS IN THIS CENTURY
APPEARS FAVORABLE

Although reductions in the Federal budget for photovoltaic energy R&D are expected to have adverse impacts, the photovoltaic industry is expected to endure and continue to make needed technological advances. Additionally, while the act's goals will probably not be achieved by 1988, achievement of the act's goals is nevertheless expected in the early to mid-1990s.

The photovoltaic industry is expected to endure even with reduced funding levels for the Federal photovoltaic energy program. The current photovoltaic market is expanding, and the long-range photovoltaic market has tremendous potential. One market research firm estimates that, by the year 2000, the photovoltaic market will be \$100 billion annually. Consequently, while a shakeout is expected in the photovoltaic industry as a result of the budget reductions, development of photovoltaic technology is expected to continue. Representatives of most firms we surveyed indicated that they intend to continue their photovoltaic efforts with Federal support at the fiscal year 1982 level. Representatives of a few firms stated that the Federal budget reductions may cause their firms to reevaluate their investment decisions in photovoltaic energy development and possibly give it a lower priority. Most large firms, however, particularly oil companies and related firms, are expected to maintain their photovoltaic energy activities. Consequently, advances in photovoltaic energy technology, resulting in reductions in photovoltaic energy system prices and increases in system production levels, are expected to continue.

While the goals of the act will most likely not be met by 1988, the development of economical photovoltaic energy systems is still expected, albeit at a later date. Industry representatives believe that the breakthroughs necessary to achieve economical photovoltaic energy systems will still be made. According to these representatives, when this will occur will depend to a great extent on the future funding levels for the Federal photovoltaic energy program. However, at the level of DOE's 1982 photovoltaic energy budget, most representatives believe that the cost goal could be met in the 1992 to 1995 time frame. Additionally, representatives of industry and market research firms expressed optimism on the future growth of the photovoltaic market. They stated that the private sector purchases are growing faster than previously anticipated, and consequently the photovoltaic market is expected to continue growth of at least 50 percent a year. One representative stated that his recent studies indicate that production could optimistically equal 1 million peak kilowatts by 1990, and the act's goal of 2 million peak kilowatts could possibly be reached a year or two thereafter. Industry officials cautioned, however, that most of the expected photovoltaic system production will be for remote applications in the United States and for overseas markets they anticipate will be coming available in that time frame, and that it may be even later before photovoltaics can be looked to for any significant contribution to the Nation's energy supply.

Consequently, despite the probable adverse impacts which industry and program officials believe will result from the budget reductions, the outlook for photovoltaic energy systems still appears favorable. The development of photovoltaic energy systems is expected to continue, although at a slower pace. While economical photovoltaic energy systems will not be attained as quickly as possible, the delays in developing this technology resulting from reducing the Federal photovoltaic energy program to the fiscal year 1982 budget levels may be only 4 to 7 years, and the widespread use of photovoltaic energy systems may yet be attained in this century.

CONCLUSIONS

Photovoltaic energy systems are an attractive energy alternative which could provide a significant source of energy for the Nation. These systems can produce electricity directly from sunlight, and can be used in virtually all areas of the country. However, the cost of these systems is currently 10 times too expensive to permit their economical use.

The Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978 directed that the Federal Government undertake an aggressive program of research and development leading to early economical use of photovoltaic technologies. The

act also mandated two goals for the program. These goals are, by 1988, to

- reduce average installed photovoltaic energy systems costs to \$1.40 per peak watt, and
- reach a total annual photovoltaic energy system production of 2 million peak kilowatts.

However, with the funding levels called for under the reduced Federal photovoltaic energy budget for fiscal year 1982, the probability of achieving these goals has been reduced. While reaching the cost goal was unlikely, there was optimism that it could be attained at previous funding levels. It now appears that this cost goal has even less likelihood of being achieved. The Federal photovoltaic energy program is not undertaking efforts which are sufficient to achieve this goal, and the photovoltaic industry is not expected to perform the R&D necessary for this goal to be reached by 1988.

The act's 2 million peak kilowatt production goal had little likelihood of being reached under past funding levels. A DOE analysis concluded that this goal had a less than 5 percent probability of being achieved at the act's projected \$1.5 billion level. Additionally, current production is at lower levels than that required to meet this goal. However, the Federal budget reductions are expected to further limit production increases, and the probability of achieving this goal is essentially eliminated.

In addition to the impacts on the goals mandated by the Solar Photovoltaic Energy Research, Development, and Demonstration Act of 1978,

- U.S. leadership in photovoltaic technology is viewed as being threatened since Federal support for the U.S. photovoltaic industry is being reduced while increased assistance is being provided by foreign governments to their respective industries, and
- small businesses in the photovoltaic industry may not survive with the reduced Federal program since they are expected to have difficulties obtaining funds needed to remain competitive with larger businesses.

However, despite these impacts, the photovoltaic industry is expected to endure with less Federal support and eventually achieve the goals, albeit at a later date. While the development of economical photovoltaic energy systems will not be achieved as quickly as possible, progress in the development of photovoltaic energy technology is still expected. Industry plans to continue in its efforts to develop photovoltaic technology, and industry

APPENDIX I

APPENDIX I

representatives believe that, with Federal funding remaining at the fiscal year 1982 level, the cost goal could be reached in the 1992 to 1995 time frame, and the production goal as early as 1991. Consequently, the use of photovoltaic energy systems to provide an economical source of electricity may yet be attained in this century.

COMPANIES CONTACTEDPHOTOVOLTAIC COMPANIES

Acurex Corporation
Ametek, Inc.
Boeing Aerospace Company
Chronar Corporation
Crystal Systems, Inc.
E-Systems, Inc.
Honeywell, Inc.
Motorola, Inc.
Poly Solar, Inc.
RCA Corporation
Rockwell International Corporation
Silicon Sensors, Inc.
Silonex
Solamat, Inc.
Solarex Corporation
Solenergy Corporation
Texas Instruments, Inc.
UTL Corporation
Westinghouse Electric Corporation

MARKETING AND INVESTMENT
COMPANIES

Advance Technology Ventures
Hambrecht and Quist
Monegon, Ltd.
Photovoltaic Energy Systems, Inc.
Solar Investors Associates
Strategies Unlimited
Wood River Capital

APPENDIX III

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W. MICHAEL MCCABE
 STAFF DIRECTOR

APPENDIX III

FORM NO. 18

HOUSE OFFICE BUILDING, WASHINGTON, D.C. 20515
 PHONE (202) 225-1000

U.S. HOUSE OF REPRESENTATIVES SUBCOMMITTEE ON ENERGY CONSERVATION AND POWER OF THE COMMITTEE ON ENERGY AND COMMERCE WASHINGTON, D.C. 20515

July 17, 1981

Mr. Milton J. Socolar
 Acting Comptroller General
 of the United States
 441 G Street, N.W.
 Washington, D.C. 20548

Dear Mr. Socolar:

In the Solar Photovoltaic Energy Research, Development and Demonstration Act of 1978, the Congress established certain objectives for the production of energy from photovoltaic technology. These objectives were to reach a total annual production of 2 million peak kilowatts and to reduce average installed system cost to \$1 per peak watt by fiscal year 1988. Since the Act's passage, the Department of Energy has devoted considerable effort toward reaching these objectives and have achieved a certain measure of progress. Still, much work remains before the Act's objectives will be realized.

Recently, however, the Administration announced major cuts in the photovoltaic R&D budget. Planned spending, which in fiscal year 1981 was to have totalled \$169 million, has been reduced to about \$63 million in the proposed fiscal year 1982 budget. The question becomes, therefore, what impact will these budget cuts have on achieving the legislatively mandated goals for photovoltaics. I would like to request that the General Accounting Office review this matter and provide a report to me as soon as possible. If you have any questions about this request, please feel free to contact Mr. Andrew Glassberg of the Subcommittee staff.

Sincerely yours.

Richard L. Ottinger

Richard L. Ottinger
 Chairman

RLO:AGrm
 (307211)

